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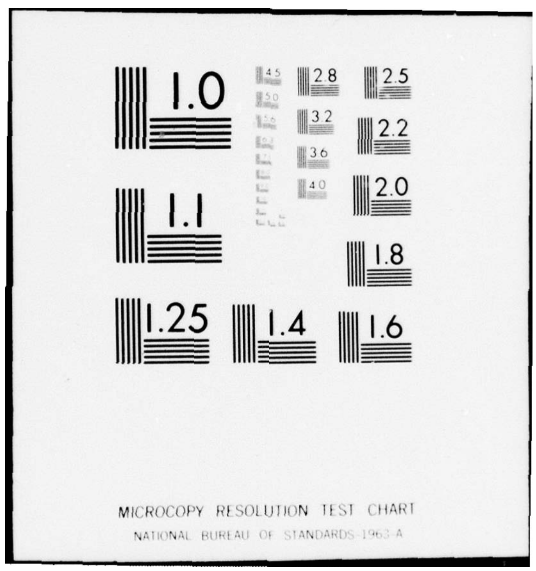
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USAARL REPORT NO. 77-7

AEROMEDICAL EVALUATION OF UH-1 INTERNAL ADVANCED PERSONNEL RESCUE HOISTS
WESTERN GEAR CORPORATION HOIST MODELS 42277R1 AND 42305R1
BREEZE CORPORATION HOIST ECP-720 MODIFICATION

BY

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US Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362

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The US Army Aeromedical Research Laboratory was tasked to provide aeromedical evaluation of advanced high performance helicopter personnel rescue hoists. Physiologic effects of increased hoist speed were evaluated and proven to be minimal at speeds of 500 feet per minute. Available helicopter electrical power provides speed up to 250 feet per minute under load limitation. State-of-the-art "off the shelf" rescue hoists were sought to provide immediate

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relief of the current "life or death" restriction of the US Army Helicopter Air Ambulance units. Safety, continuous cycle function, improved speed and increased operational capabilities were specifically evaluated. The Western Gear Corporation two speed hoist met the design and operational requirements.

7. AUTHOR(S) - (Continued)

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SUMMARY

Aeromedical evaluation of advanced state-of-the-art helicopter personnel rescue hoists was conducted by the US Army Aeromedical Research Laboratory. The Western Gear Corporation's single speed (125 feet per minute) Type 42277R1 and two speed (125 feet per minute 600 pound/250 feet per minute 300 pound) Type 42305R1 and the Breeze Corporation ECP-720 configuration single speed (125 feet per minute) hoists were evaluated. Study of aircraft compatibility, man-machine interface, safety function, and operational mission functions was conducted. The Western Gear Corporation two speed hoist provided advanced state-of-the-art operational capabilities and safety features considered to release the current "life and death" restrictions. Continuous duty cycle, safety redundancy, modular components, and using unit maintenance and cable change capabilities were demonstrated to support required operational needs. Man rating of the two speed Western Gear hoist was accomplished.

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AEROMEDICAL EVALUATION OF UH-1 INTERNAL ADVANCED PERSONNEL RESCUE HOISTS
WESTERN GEAR CORPORATION HOIST MODELS 42277R1 AND 42305R1
BREEZE CORPORATION HOIST ECP-720 MODIFICATION

BACKGROUND

The Surgeon General by letter, MEDDD-PA, 21 Nov 62, subject: Request for Hoisting Device for UH-1B and UH-1D Air Ambulance, stated a requirement for a hoisting device for helicopter evacuation of patients. As a result of this requirement, the US Combat Development Command Agency prepared a Small Development Requirement (SDR), 23 Jan 63, entitled "Small Development Requirement for UH-1B and UH-1D Hoist." While the SDR was being processed, the Bell Helicopter Corporation developed a hoist for use on UH-1B and UH-1E helicopters used by the Australian AF and the US Marines. Due to structural difference in the roofs of the UH-1B and UH-1D helicopters, a modification was required to install this hoist in UH-1D aircraft. Bell Helicopter Corporation, however, proposed to design and fabricate a "plug in" type hoist (quickly installed or removed) which would meet the Army requirements. Following development of a prototype, the hoist was installed in a UH-1D helicopter and evaluated by the German Armed Forces.[1] The hoist, manufactured by Breeze Corporation, was subsequently accepted and used in the conflict in the Republic of Vietnam with satisfactory results. Since this initial use, the joint services have reported accidents involving military and civilian personnel of both fatal and near fatal injury.

Six severed cable incidents occurred with the USAF UH-1 Internal Rescue Hoist at Survival School training sites.[2] The USAF initiated a Critical Design Review (CDR) in February 1973. The CDR by the USAF resulted in an Engineering Change Proposal (ECP) 720. The US Army Aviation Systems Command (AVSCOM) also provided a Staff Study of the hoist modification. As a result of this study, a Product Improvement Proposal (PIP) (1-75-01-115A) was updated to the USAF ECP-720 configuration.

The USAF has modified only 13 hoists to the ECP-720 configuration. Of this number four failures have occurred. Three failures were attributed to the level wind mechanism and one failure ascribed to the clutch assembly. The level wind failures occurred at the low use times of 1.0, 5.5, and 18.7 hours. The clutch assembly failed at 2.3 hours. This reliability data and the overhaul time limit reduction from forty hours to twenty hours on hoist frame and reduction to five hours for cable replacement indicate failure of expensive modification to provide a "fix" of current hoist defects.[3]

To provide further evaluation of available state-of-the-art developmental advances in helicopter hoists, the US Army Aeromedical Research Laboratory (USAARL) provided a "hands on" physiologic and acceleration data review of the Lockheed kinetic energy High Performance Helicopter Hoist.[4]. This hoist, however, remains an experimental model and could not be considered an immediate solution to the life or death hoist restriction.

Available "off the shelf" helicopter personnel rescue hoists were obtained for evaluation of current "state-of-the-art" capabilities. Hoists were obtained from the Western Gear Corporation and the Breeze Corporation for aeromedical evaluation.

HOIST DESCRIPTIONS

Western Gear Corporation Hoist

A production model Internal Helicopter Rescue Hoist was developed by the Western Gear Corporation (WGC) for the Iranian helicopter 214 (essentially the UH-1H). To evaluate suitability for the US Army aeromedical needs, four standard hoists with a maximum retrieval speed of 125 ft/min, part number 42277R1, and one hoist with a maximum speed of 250 ft/min with 300 pounds and 125 ft/min with 600 pounds, part number 42305R1, have been procured under DAMD 17-74-C-4116 for aeromedical testing by the US Army Aeromedical Research Laboratory (USAARL). These hoists are electrically powered with electrical/electronic controls. The hoist operator utilizes a variable speed control located in a pendant control grip assembly. A fixed speed control is available to the pilot at 100% nominal rate. The WGC hoists have 250 feet of usable cable. The hoist system consists of six components:

1. Winch assembly.
2. Boom assembly.
3. Boom head with traction sheave assembly.
4. Boom position actuator.
5. Structural support assembly.
6. Control pendant.

The initial two WGC hoists, numbers 131 and 132, Western Gear Hoist model number 42277R1, were received 24 June 1975. At this time only 18 hours of operational time had been accumulated by a similar hoist in a UH-1 helicopter at Bell Helicopter Corporation (BHC) plant.

Breeze Corporation Hoist

The USAF agreed to provide an ECP-720 modification kit to install on a USAARL provided Breeze hoist.[5] To obtain the ECP-720 modified hoist for evaluation, USAARL was required to return the complete hoist to the USAF.[6]

The USAARL Breeze hoist assembly BL-8300-4 was delivered to Breeze Corporation, Inc., Union, New Jersey, for ECP-720 modification. Upon

completion of the modification kit, the ECP-720 Breeze hoist was designated as serial number HX00039, Bell Number 212-070-343-1, FSN 1680ND095738 LGA, and returned to USAARL on 20 November 1975.

The ECP-720 Breeze hoist (720 BH) was assembled from the following components:

Control Box	Serial 1019C	RG 1280
Sheave	Serial 254C	RG 1307
Hoist	Serial 291C	RG 1268
Bell 205-072-311-1		RG 1375
Pendant Control	Serial 998C	RG 1375
Roller BL 13802		RG 1375

The 720 BH is an electrically powered variable speed control hoist with the rated capacity to raise or lower 600 pounds at 125 feet per minute.

MATERIALS AND METHODS

The USAARL evaluation was concerned with the hoist performance as meeting the current Required Operational Capability for High Performance Utility Helicopter Hoist with exception of hoist retrieval speed.[7] The evaluation concentrated on the following operational areas:

a. Man-machine interface.

b. Overall mission applicability (life or death restriction).

c. Data profiles of hoist performance.

The USAARL JUH-1H helicopter was utilized for the operational evaluation. The 720 BH and WGC hoists were routinely installed by crewchief and medical corpsman. Ground operational checks were performed as designated by the USAARL Biomedical Test Plan, Appendix B.[8]

ECP-720 B Hoist

ECP-720 BH data collection was obtained by a Lockheed 7-channel battery-operated tape recorder. The helicopter-hoist power cable was used to obtain voltage drop at time of hoist operation. Temperature of the winch and motor was obtained by thermocouples (National Semiconductor Corporation LX5700) attached to the surface of the respective housing. Precision electrical strain gauges (Micro Measurement Type ED-08-375BG-120) were attached to the vertical strut of the structure support assembly. The strain gauges were applied to the compression and tension surfaces of the boom structure support assembly and boom head support. The strain gauges were electrically calibrated by a known load applied to the hoist. The output of the strain gauges was routed through a Vishay Ellis-10

strain gauge amplifier to a Burr Brown amplifier powered by a Philbrick Researchers PR-30 power supply.

A tachometer using a precision potentiometer (Technology Instrument Corporation) RVI-1/2-S2 was installed by direct drive to record the rotation of the sheave assembly. The tachometer was calibrated to provide one revolution of the electrical potentiometer equal to 0.979 feet of cable travel. Cable speed was calculated by:

a. Peak to peak of printout = one revolution

b. Time =

$$\frac{\text{peak to peak (inches) of potentiometer output X conversion (millimeters/inches)}}{\text{paper speed (millimeters/minute)}}$$

c. Cable speed = $\frac{\text{0.979 feet}}{\text{time (minutes)}}$

Calculated data from recording included:

a. Onset of load.

b. Cable speed.

NOTE: Due to the nonlinear type tachometer recording of acceleration or overtravel data could not be defined.

Evaluation of compatibility with litter, sling assembly, and forest penetrator was accomplished to provide a comparative data base.

WGC Hoist

Data collection for the WGC hoists from instrumentation was obtained from a Lockheed 7-channel battery-operated tape recorder. The helicopter-hoist power cable was used to obtain voltage drop at time of hoist operation. Temperature of the winch and motor was obtained by thermocouples (National Semiconductor Corporation LX5700) attached to the surface of the respective housing. Precision electrical strain gauges (Micro Measurement Type ED-08-375BG-120) were attached to the vertical strut of the structure support assembly. The strain gauges were applied to the compression and tension surfaces of the boom structure support assembly and boom head support. The strain gauges were electrically calibrated by a known load applied to the hoist. The output of the strain gauges was routed through a Vishay Ellis-10 strain gauge amplifier to a Burr Brown amplifier powered by a Philbrick Researchers PR-30 power supply.

A tachometer (Servo-Tec Type SB-140B-1) was inserted through the side cover of the boom head to record the rotation of the sheave assembly.

This was electrically calibrated to provide the cable speed during ascent and descent in feet per minute.

Calculated data from the data recording obtained included:

1. Acceleration--positive and negative.

2. Overtravel of cable following release of power.

3. Applied load (effective load due to G).

This initial data was obtained in the operational environment to familiarize operators and aircrew with WGC hoist function. A second goal was to obtain repeated use of the hoist to simulate field use.

Use of the litter, sling assembly, forest penetrator, and human lifts was accomplished for compatibility with standard rescue devices.

NOTE: The hoist missions initially utilized concrete blocks of known weight. Oscillations encountered with the higher altitudes provided unsafe flight conditions. Subsequently, a cargo net utilizing sand bags of known weight was employed for actual load. The use of these large, bulky loads, however, prevented in-flight evaluation of the boom position actuator bringing the load into the aircraft cabin.

Static ground tests were utlized to evaluate position actuator under load for the ECP-720 BH and WGC hoists.

RESULTS

Installation

Time Required for ECP-720 BH. The anchoring lugs to floor and overhead hardpoints of the ECP-720 BH and WGC were unchanged from original Breeze hoist. Time to accomplish installation for a two-man crew, medical corpsman and crewchief, without experimental instrumentation was five minutes to ten minutes with an average of six minutes. Special tools were not required for installation/removal. Installation was considered subjectively easily accomplished; however, the floor and ceiling anchor studs required use of wrench and screwdriver.

Time Required for WGC Hoists. The installation/removal of the WGC hoists was accomplished in a similar manner to the original Internal Personnel Rescue Hoist manufactured by Breeze Corporation (BC). The crewmembers rapidly became familiar with installation. Time to accomplish installation for a two-man crew without instrumentation was three to eight minutes with an average of five minutes after minimal familiarity. Tools were not required for installation/removal. Installation was considered overall to be easily accomplished by all crewmembers.

Hoist Effect on Cabin Space and Door

Photographs A, C, E, and G illustrate the WGH hoist effect on entrance door and cabin space compared to the Breeze ECP-720 hoist photographs B, D, and F. Conservation of entrance door space, as well as absence of actuator base plate, is noted in photographs of WGH.

The 720 BH occludes the area adjacent to the floor deck of the cabin by the hoist motor. The boom actuator and plate also extend in the floor area of the cabin.

The capability to unpin the actuator of the ECP-720 BH to rotate the boom to a position perpendicular to longitudinal aircraft is considered to be an advantage to maintain available door opening when hoist use is not anticipated (Photograph H). Crashworthiness was not determined in this position.

Operational Preflight and Postflight Checks - WGC Hoists

The checks were accomplished as shown by Appendix B of USAARL Biomedical Test Plan.[9] Hoist numbers 131, 132, 133, and 135 functioned within the specified operational constraints. Defects and/or operational idiosyncracies noted are as follows:

1. The cable travel through the distal boom head during ground check could be abraded by the rough edges of a steel guide plate covering the aluminum housing. This possibility in flight would be lessened by the more vertical position of cable feed. It does, however, remain a potential threat to cable integrity.

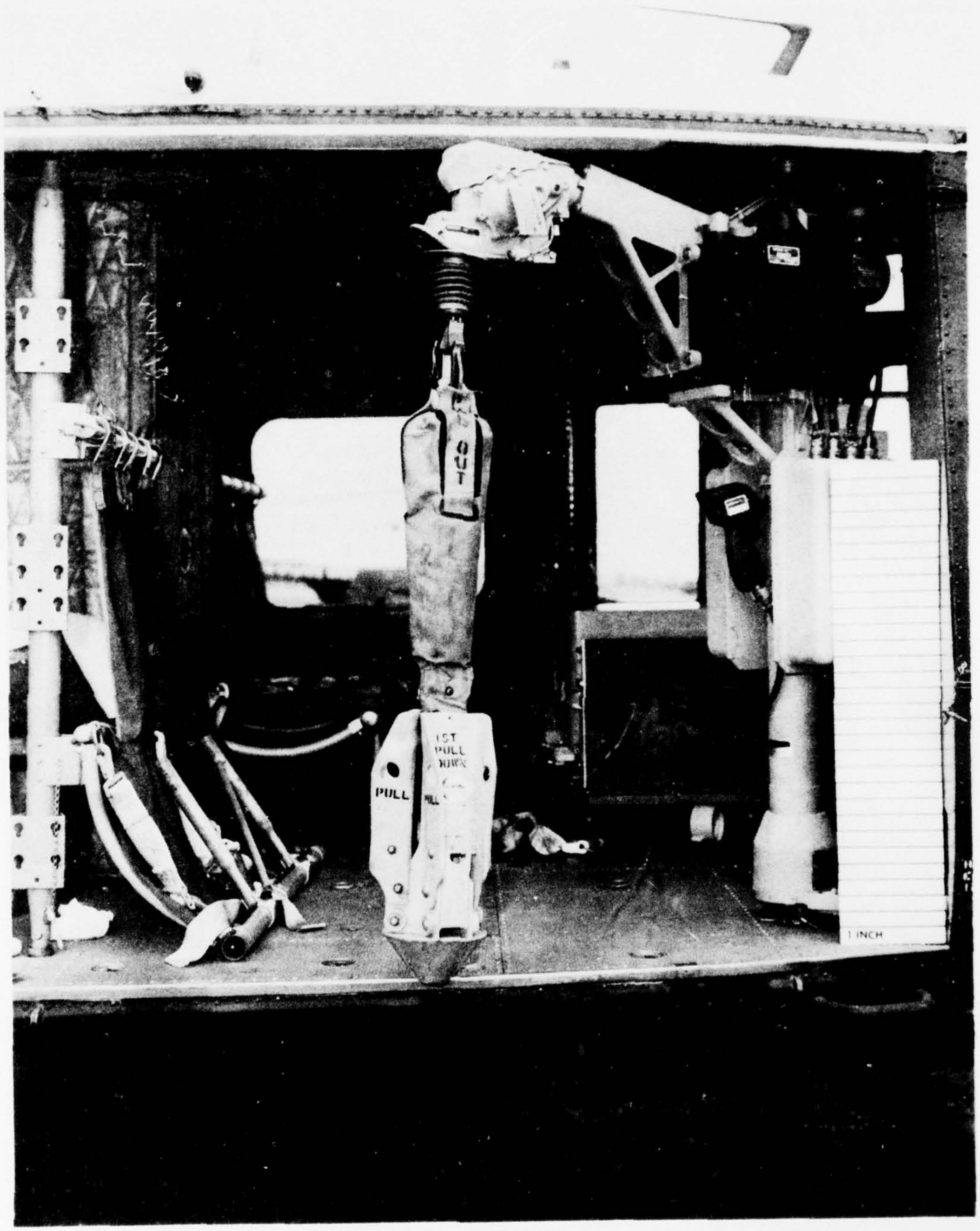
2. The boom position control cannot be overridden by pilot. The function of boom position is determined by the initial input, either pilot or operator. Hoist ascent/descent function, however, does remain an override option of the pilot.

3. The possibility of radar or intense electromagnetic radiation actuating the cable cut detonator was considered. It is considered that weather radar, ground control radar, and other sweep devices would be of inadequate strength. A point source high intensity directed radar beam could be considered as a possible source of inadvertent cable cut. Usual avionics radiation is considered of insufficient intensity.

Operational Preflight and Postflight Checks - ECP-720 BH

Defects and/or operational idiosyncracies are as follows:

a. Attachment of base plate to cabin floor required a wrench or vise grip pliers to attach securely. This required additional effort on the part of the crewchief to insure the hoist was secure.



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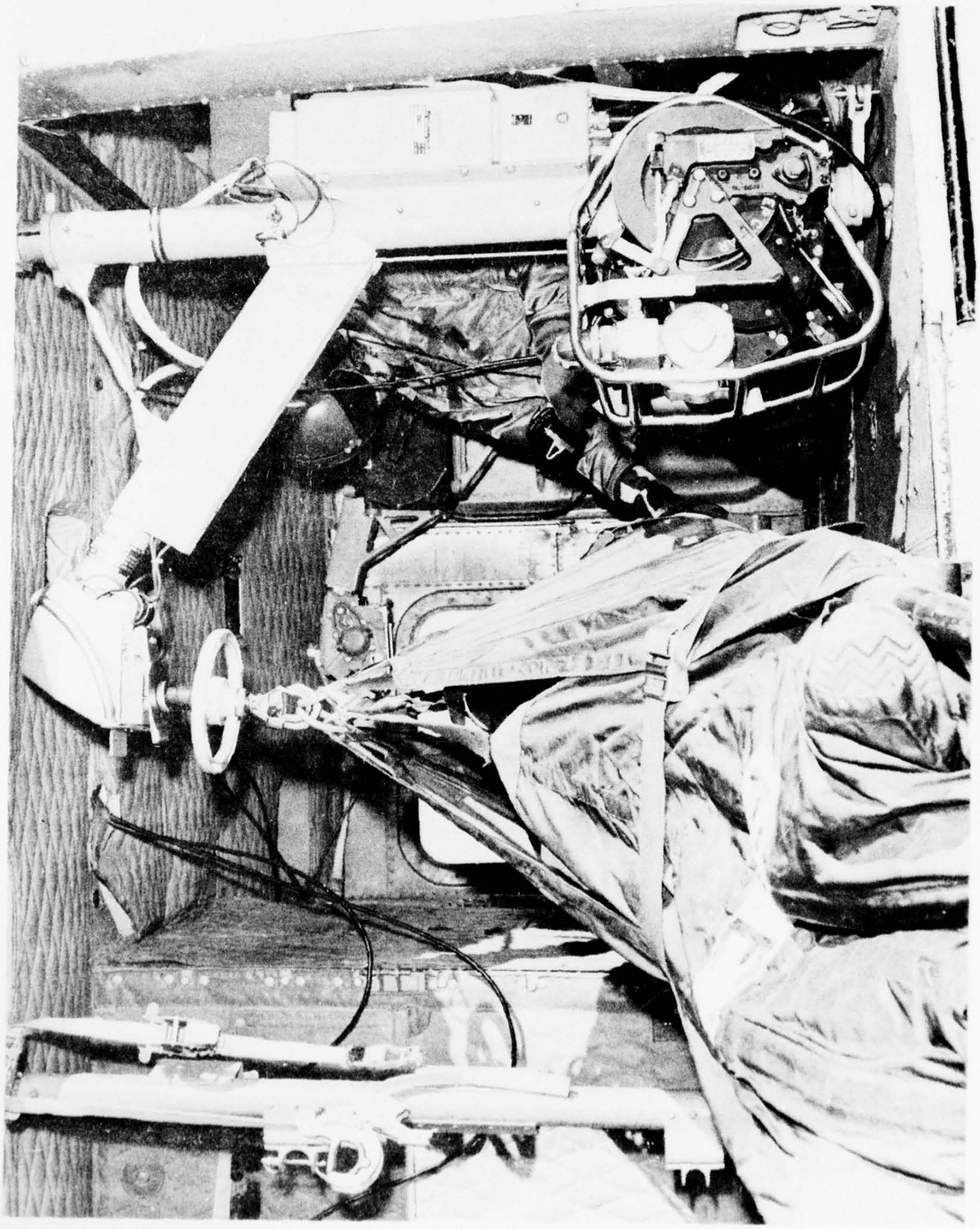

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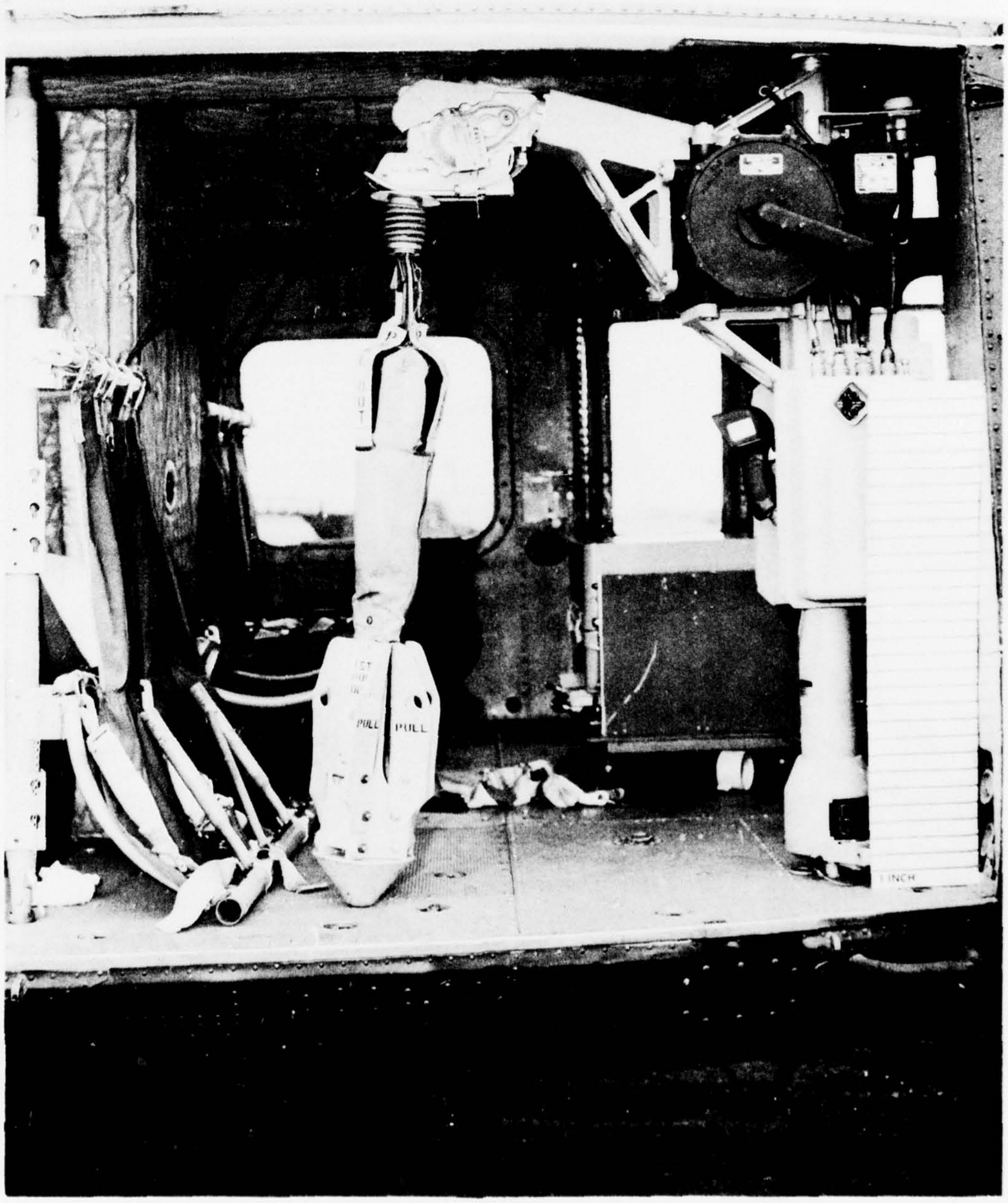

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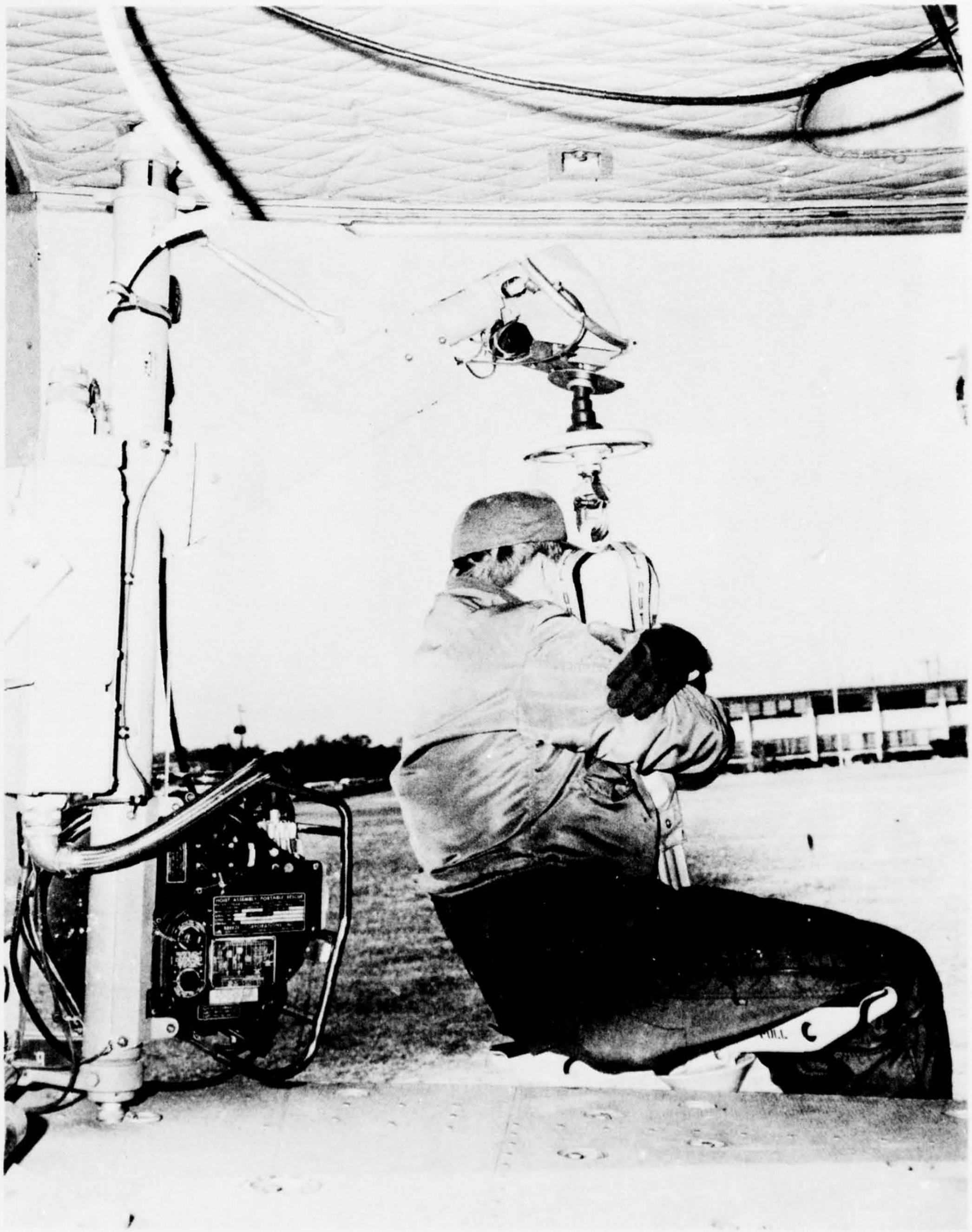

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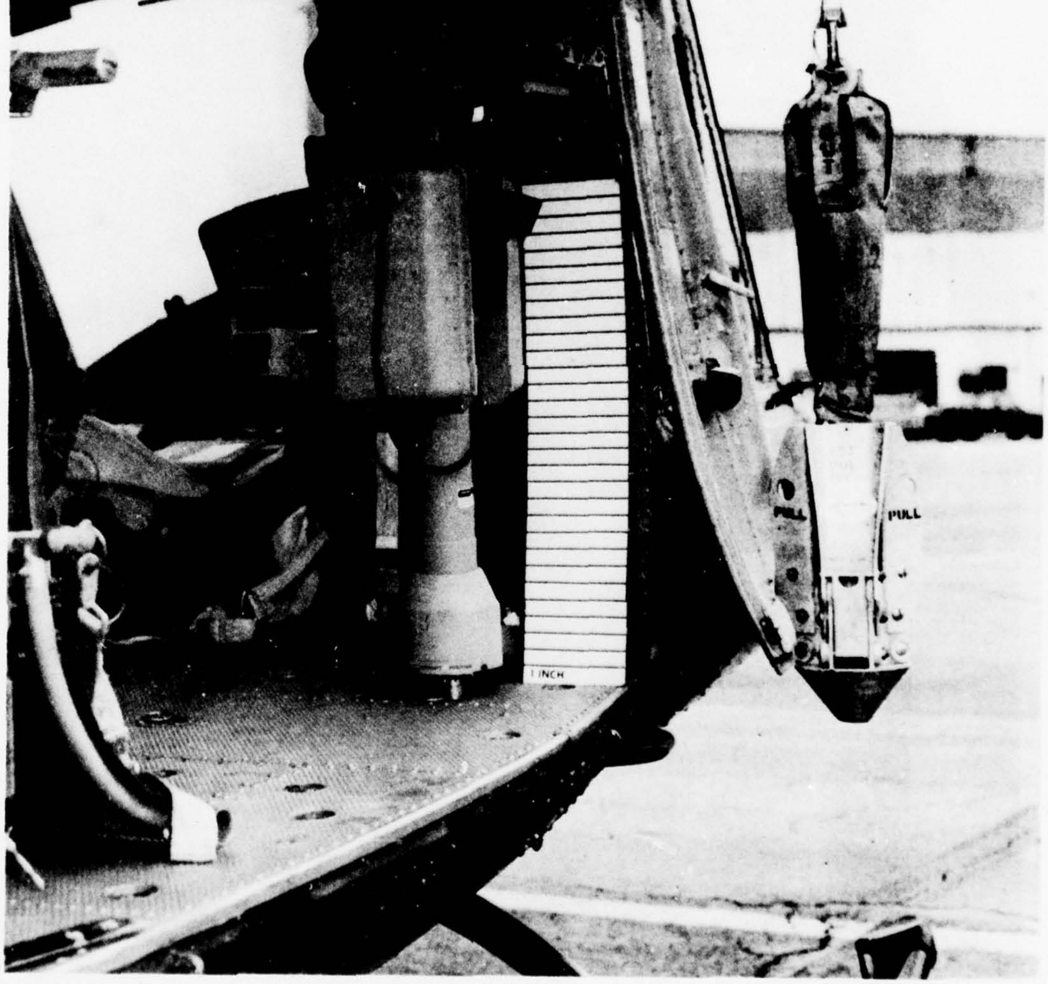

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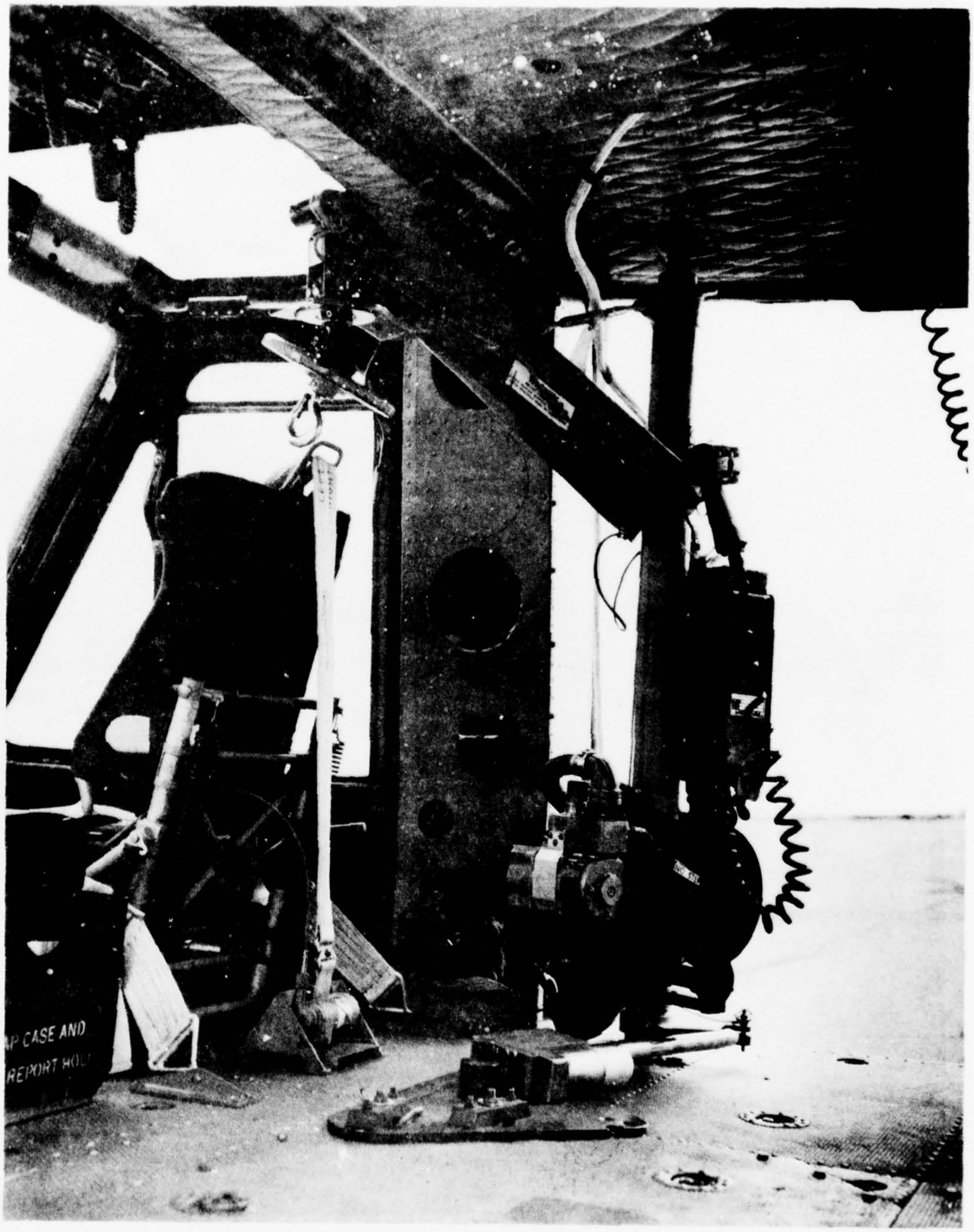


PHOTO H

b. Oil level of the hoist was difficult to visualize when installed in aircraft.

c. The possibility of intense electromagnetic radiation activating the cable cut detonator was considered. Usual avionics radiation is considered of insufficient intensity.

d. The cable is exposed during the travel parallel to boom. This represents an area of potential damage and/or personnel hazard (Photograph I). Cable is also capable of being fouled on level wind (Photograph J).

Inflight Operational Hoist Data - ECP-720 BH

Table I tabulates the data obtained from the noninstrumented hoist.

TABLE I

NONINSTRUMENTED DATA--HOIST 720 BH

NR. OF HOISTS	ALTITUDE	WEIGHT	REMARKS
7	100	308	Familiarization
1	100	308	Oscillation of load caught on skid; CABLE BREAK and floor anchor stud break
16	100	308	Familiarization
10	250	308	Oil overflow sprayed throughout cabin; speed subjectively decreases as hoist temperature increased
23	50	200	---
21	100	200	---
24	250	200	---
25	50	300	---

Table II provides the data from the instrumented hoist.

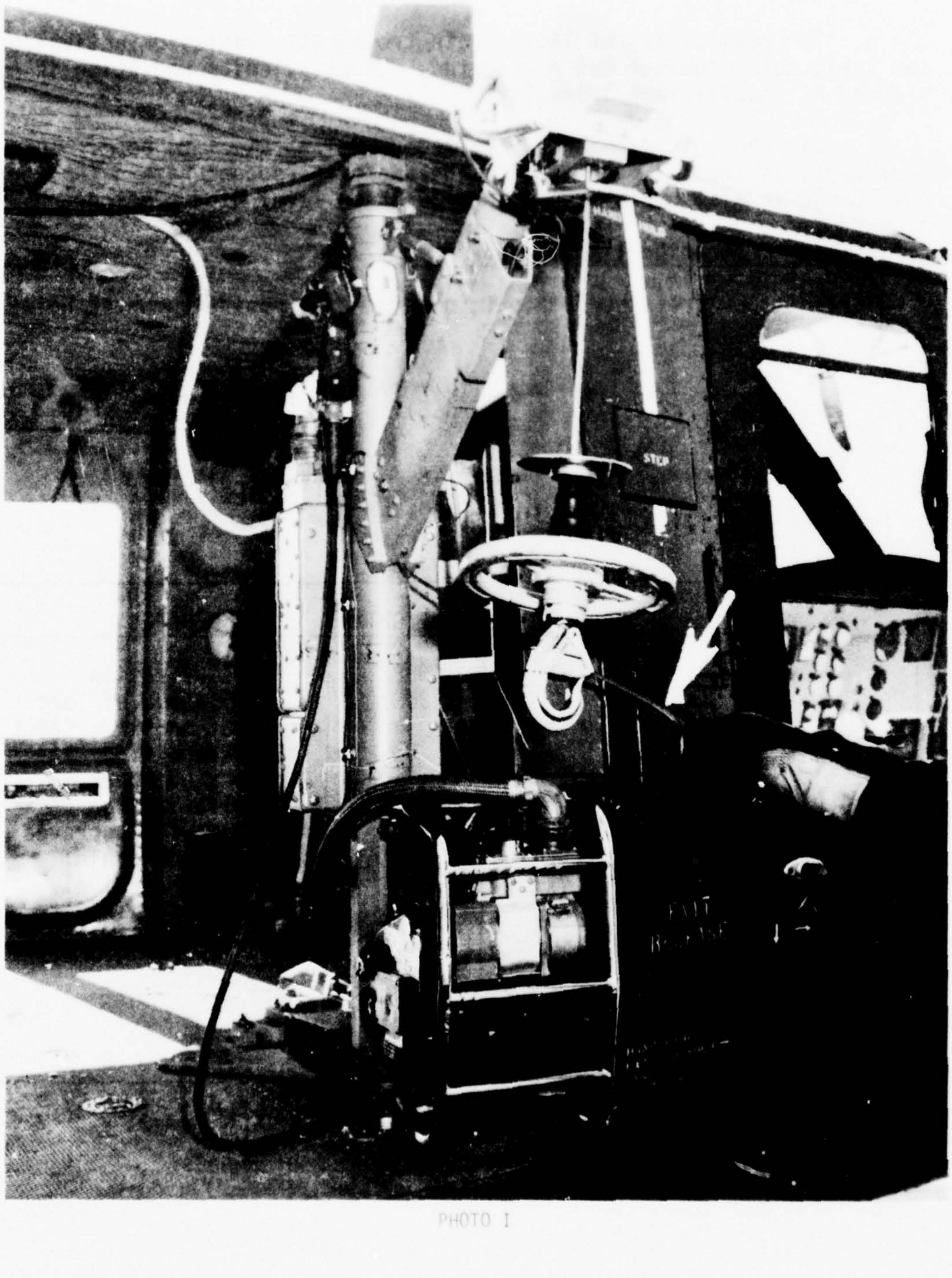


PHOTO I

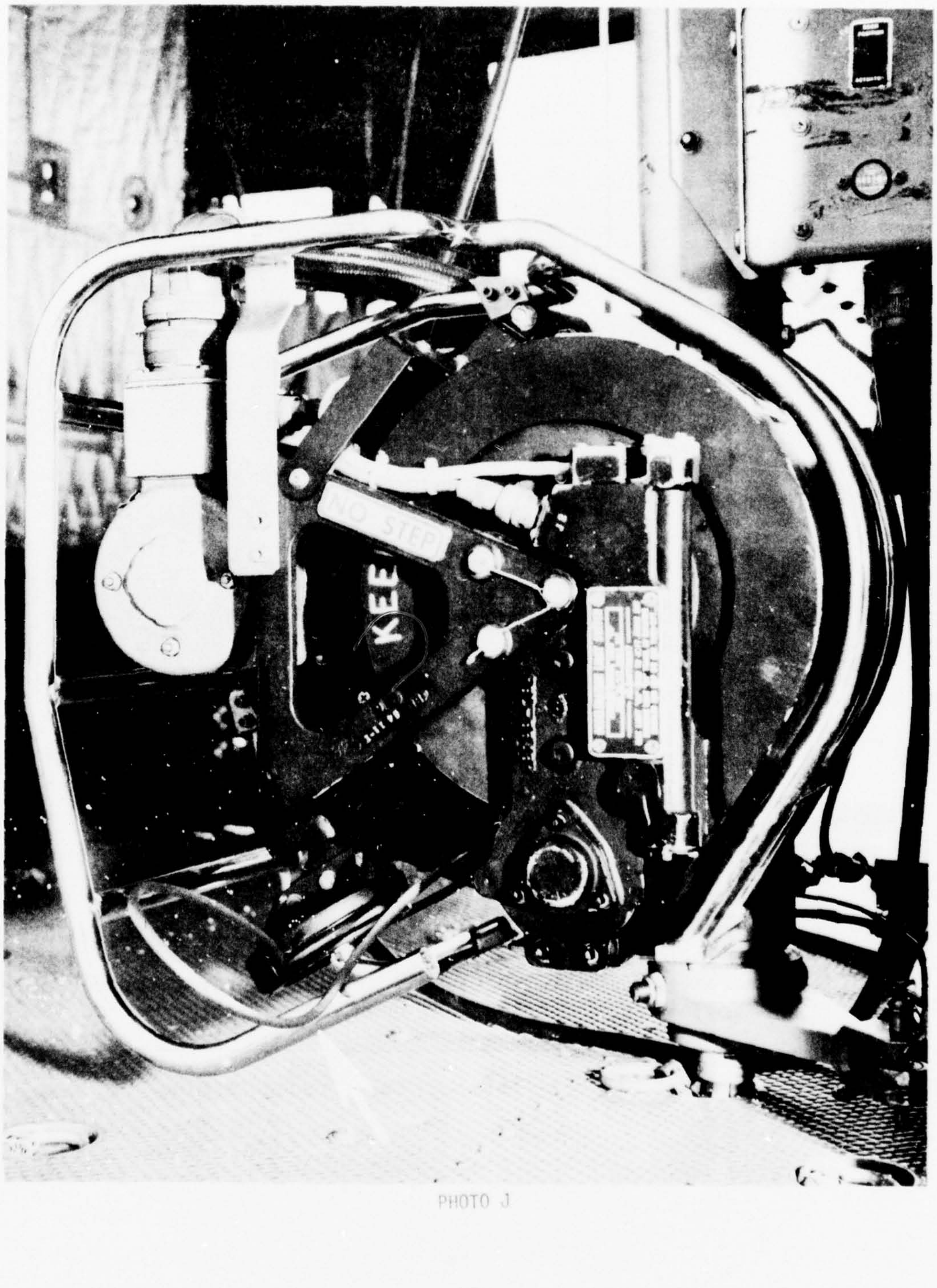


PHOTO J

TABLE II

INSTRUMENTED DATA--HOIST 720 BH

CYCLES	ALTITUDE (Feet)	WEIGHT (Pounds) Tension Load	CABLE SPEED FPM Average (Range) UP	DOWN	TEMP°C	REMARKS
5	50	300	128.8 (128.8-132.3)	148.6 (148.3-150.6)	---	
5	100	300	132.3 (128.8-134.1)	152.4 (148.3-155.4)	---	
5	250	300	132.3 (128.8-134.1)	152.4 (148.3-155.4)	---	
5	50	500	117.9 (117.9)	150.6 (148.3-155.4)	---	
5	100	500	121.9 (117.9-128.8)	155.0 (148.3-160.5)	---	
5	250	500	119.7 (117.9-120.9)	155.5 (150.6-160.5)	---	
5	50	600	119.7 (117.9-122.4)	154.1 (148.3-163.2)	---	
5	100	600	117.3 (113.8-120.9)	158.6 (155.4-163.2)	---	
5	250	600	120.6 (117.9-122.4)	160.4 (155.4-163.2)	---	
			AVERAGE SPEED 123.4	154.2		
1	50	600	---	---	25.5°C	Initial Oil temp
4	250	600	---	---	50°+C	See **

**Oil temp increased to above 50°C. Oil overflow sprayed throughout aircraft. Following 38 minutes cool down, temperature reached 49°C.

Figures 1 and 2 illustrate data obtained for speed determination.

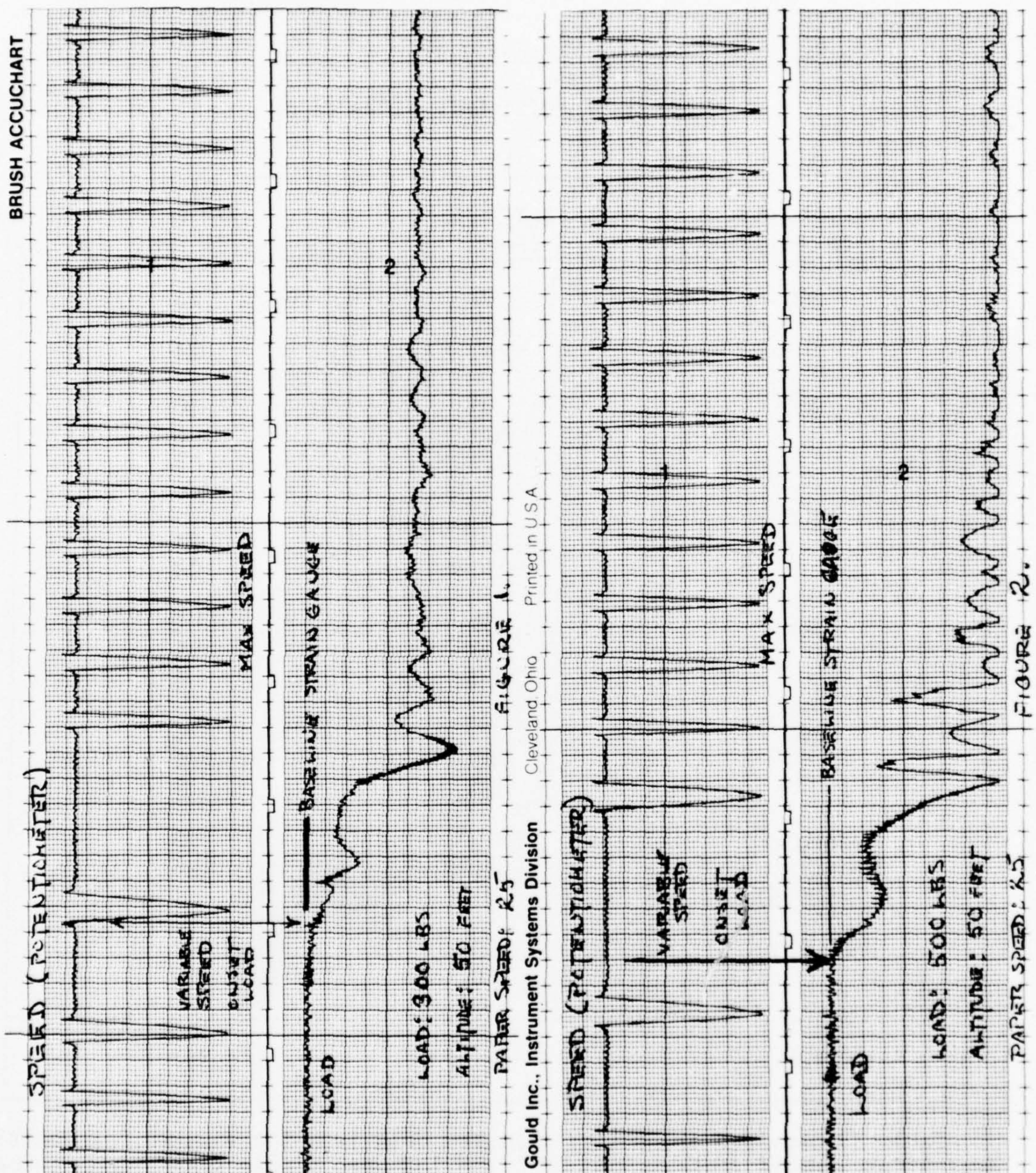


FIGURE 1.

FIGURE 2.

Table III summarizes the hoist function at each altitude and weight.

TABLE III

SUMMARY OF HOIST DATA--ECP-720 BH

WEIGHT (Pounds)	ALTITUDE (Feet)	HOIST 720 BH (125 FPM)
200	50	23
	100	21
	250	24
300	50	30
	100	5
	250	5
308	50	
	100	24
	250	10
500	50	5
	100	5
	250	5
600	50	6
	100	5
	250	9
Jungle Penetrator (20.5)	50-80	28
	100-150	25
Hook Only	100	2
	250	10
TOTAL		242

Table IV provides the noninstrumented data from the Western Gear hoist evaluation. Hoist numbers 131, 132, and 133 were single speed model number 42277R1. Hoist number 135, model number 42305R1, was emphasized as the two speed capability is considered advantageous to helicopter combat survivability.

TABLE IV

NONINSTRUMENTED DATA - WGC

HOIST NR. (DATE)	NR. OF HOISTS	ALTITUDE	WEIGHT	REMARKS
132 (25 Jun)	1 1 1	50 Ft. 100 Ft. 50 Ft.	0 0 200	Familiarization. Familiarization. Failed to respond to UP command. Control panel returned to WGC.
131 (26 Jun)	4 2 1 1 1 1	30 Ft. 50 Ft. 20 Ft. 100 Ft. 250 Ft. 30 Ft.	400 400 600 200 200 160	Familiarization Familiarization. Familiarization. a. Excessive hook spring compression due to micro switch malfunction. b. Oscillation of load produced 1/2" travel at rotator arm.
131 (27 Jun)	0			Hoist failed to respond to pendant command.
131 with pendant 132 (7 Jul)	0			Pendant of the 132 was installed; appeared initially to function adequately. Preflight check--the finding of BOOM OUT command also gave cable down. Oil leak of boom head noted.
131 with control panel (CP) 132 & pendant (PN) 132 (9 Jul)	4 1 1	25 Ft. 100 Ft. 250 Ft.	200 200 200	50% deceleration set at 7 feet (1 foot ± below skid). On recover of empty hook, the hook oscillated and impacted the boom head treadle with marked compression. Could not be reduplicated.
131 (CP 132) (PN 132) (18 Jul)	0			Cable cut by untrained technician. Cable cutter functioned properly.

HOIST NR. (DATE)	NR. OF HOISTS	ALTITUDE	WEIGHT	REMARKS
132 (CP132)(PN132) (12 Aug)	10 10	50 Ft. 100 Ft.	300 300	Malfunction of overtemp and caution lights (L) panel on ground check. Post flight check function adequate. Oil leak winch housing (returned to WGC).
132 (CP132)(PN132)	10	250 Ft.	300	
133 (19 Aug)	8 10	100 Ft. 50 Ft.	300 300	50% decel at 15 feet below skid.
133 (26 Aug)	11 5	50 Ft. 100 Ft.	300 300	
133 (6 Sep)	15 8	50 Ft. 100	300 300	Vibration
133 (26 Sep)	10 10 10	50 Ft. 100 Ft. 250 Ft.	200 200 200	
133 (29 Sep)	9 10	50 Ft. 100 Ft.	600 600	Vibration
133 (30 Sep)	18	250 Ft.	600	Vibration

HOIST NR. (DATE)	NR. OF HOISTS	ALTITUDE	WEIGHT	REMARKS
133 (28 Oct)	10	40 Ft.	300	1. Boom head oil seal leaking. 2. Rubber compression boot at hook loose. 3. 10 lift in 8 minutes failed to produce vibration.
	5	40 Ft.	450	No vibration.
	6	160-175	450	1. Slight vibration on initial hoist after 7 min. cooling. 2. On 6 hoist after start-stop, marked vibration.
	13	130-150	450	1. Recurrent vibration on <u>descent</u>. 2. At termination of this test, oil change in boom head required due to tachometer removal.
133 (13 Nov)	5 5	50 Ft. 80 Ft.	Jungle Penetrator	Noted strand separation of cable at 5-7 ft. from hook.
(14 Nov)	1 4 3	80 Ft. 65 Ft. 50 Ft.		
133 (17 Nov)	4 10 5	100-120 80-90 50-65	Jungle Penetrator	Vibration began on 15 lift. Could be felt in floor of A/C.
135 (30 Oct)	10 19 2	50 Ft. 150 Ft. 250 Ft.	300 300 300	No vibration noted.
135 (31 Oct)	50 3*	20 Ft. 10 Ft.	300 500	*3 lifts were made in high speed mode with weight overload (500 lbs). Hoist would "stall" after lift of 4-6 inches.

HOIST NR. (DATE)	NR. OF HOISTS	ALTITUDE	WEIGHT	REMARKS
135	10	100 Ft.	300	Temperature overheat light on with all lifts.
(19 Nov)	13	250 Ft.	300	*2 lifts in high speed mode with weight overload (500 lbs). Hoist would "stall"
	2*	10 Ft.	500	after lift of 6-8 inches.
	15**	100 Ft.	500	**15 lifts were made utilizing low speed mode.
135	10*	50 Ft.	600	All lifts low speed mode.
(21 Nov)	7	100 Ft.	600	*Vibration noted on lift 3 at 50 ft, 600 lbs., and lift 6, 250 ft., 600 lbs.
	10**	250 Ft.	600	**Temperature overheat light on after lift 4, 250 ft, 600 lbs. Remained on throughout remainder of lifts.
135	29	100 Ft.	300	Temp overheat light.
(13 Nov 75)	19	250 Ft.	300	
135	17	50 Ft.	200	Temp overheat light.
(14 Nov 75)	17	100 Ft.	200	
	17	250 Ft.	200	
	3	50 Ft.	300	Temp overheat light. 250 FPM
	7	50 Ft.	300	125 FPM
	12	100 Ft.	300	125 FPM
135	28	50 Ft.	300	250 FPM
	12	100 Ft.	325	125 FPM
	20	250 Ft.	0	250 FPM Hook only
135	6	50 Ft.	175	125 FPM Salt water, human subject for man rating.
	12	100 Ft.	175	250 FPM Salt water, human subject for man rating.
	8	200 Ft.	175	250 FPM Salt water, human subject for man rating.

Table V tabulates the instrumented data for WGC single speed hoist number 133 and two speed hoist number 135.

Table VI summarizes by hoist numbers the lifts at each altitude and weight.

Figures 3 and 4 illustrate sample data acquisition of the velocity/ acceleration profile recorded from the instrumented WGC hoists numbers 133 and 135.

General Comments

The operation of the Breeze ECP-720 and the WGC single and two speed hoists was technically simple. Minimal instruction was required to become operationally proficient.

Repeated lifts of the series of weights at altitude were accomplished within the scenario prescribed.[7]

The weight, retrieval/descent speed, and overall function were within the design constraints with the exception of average retrieval speed of the Breeze ECP-720 of 123.4 (design 125 FPM).

The standard pendant control was utilized. Comparison of the 720 BH pendant with the two configurations proposed by Western Gear is provided in Photograph K. The 720 BH pendant provides the most appropriate angle for variable speed control using the thumb. The WGC configurations are considered satisfactory. The weight of each pendant is considered acceptable. The weights in pounds are shown in Photograph L.

Cable marking was available on the WGC hoists to assist in providing visual cues to the operator. This was found to be of marked value. The Breeze ECP-720 had only initial and terminal cable markings.

Specific Comments - WGC Hoists

WGC SN 132 failed to respond to hoist down or up command in its initial test. Failure analysis by WGC demonstrated a loose connection on a shunt wire.[9] Verbal report (unpublished data) by Mr. Don Shutt, WGC Engineer, indicated service tests by WGC proved the K-5 relay was inadequate and was replaced by heavy duty K-5.

WGC SN 131 failed when commanded to "boom out" as it produced "boom out" and "reel out" of cable. Pendant failed to respond to "down" command. Analysis by WGC determined the connector of control panel was "cross-pinned." Initial WGC verbal report indicated electronically it could not occur. Cross-pinning is apparently capable of producing this defect. Pendant failure ("coolie hat" type) was due to microswitch malfunction.[9]

The 20-foot caution light mounted on the control panel box was of little value in hoist operation. The operator is concerned with the

TABLE V

INSTRUMENTED DATA - WGC

HOIST NR. (DATE)	CYCLES	ALTITUDE FEET	WEIGHT POUNDS (Tension Load)	CABLE SPEED (Feet Per Min.) Average (Range) 100% SPEED	50% SPEED	OVERTRAVEL Inches Up 50% (Range) Inches Up 100% (Range) Feet Down (Range)	ACCELERATION Feet/Sec/Sec	TEMP °C Motor--Winch [Increase] (Nr. of Lifts)	REMARKS
133 [27Aug]	15	50	300 (300)	146.4A (140-148) 174.4D (166-175)	82 (78-85)	2.4" (2.3-2.7) 11.8" 2.99' (2.7-3.2)	-3.25 (2.47-4.74) -3.45 (2.99-3.79) -5.33 (5.06-5.78)	63°--77° 63°--85°[8](5) 63°--96°[19](15)	Lift number 15 performed by pilot control
133 [27Aug]	15	100	300 (300)	148.0A --- 175.0D ---	84.1 (78-85)	2.47" (2.3-2.5) 11.82" (11.8-11.84) 3.02' (2.9-3.2)	+3.24 (2.13-4.56) -3.33 (3.17-3.58) -5.43 (4.86-6.08)	63°--96°	Vibration on descent first noted on lift 11
133 [28Aug]	15	50	400 (431)	139.7A (138-140) 172.9D (160-182)	74.27 (70-78)	2.26" (1.9-2.7) 8.87" (8.4-9.8) 2.69' (2.1-3.0)	+2.52 (2.15-2.90) -3.75 (3.43-4.05) -5.33 (4.41-5.87)	55°--76°	
133 [28Aug]	10	100	400 (420)	139.8A (138-140) 175D ---	78 ---	2.22" (1.9-2.5) 8.18" (7.7-8.4) 2.71' (2.45-2.9)	+2.86 (1.56-3.96) -3.77 (3.51-3.94) -5.25 (4.50-5.79)	55°--76° 55°--82°[6](4) 55°--96°[20](9)	

NOTE: A = Ascent
D = Descent

HOIST NR. (DATE)	CYCLES	ALTITUDE FEET	WEIGHT POUNDS (Tension Load)	CABLE SPEED (Feet Per Min.) Average (Range) 100% SPEED	CABLE SPEED 50% SPEED	OVERTRAVEL Inches Up 50% (Range) Inches Up 100% (Range) Feet Down (Range)	ACCELERATION Feet/Sec/Sec	TEMP °C Motor--Winch [Increase] (Nr. of Lifts)	REMARKS
133 [29Sep]	2	50	600 (600)	140.0A --- 178.0D ---	78 ---	2.34" --- 5.6" --- 2.66' (2.34-2.97)	+2.88 (2.36-3.41) -5.03 (4.64-5.42) -5.91 (5.37-6.45)	30°--30°	AMPS peak 246 Sustain 184 50%Peak 170,Sustain60 Peak 246, Sustain 60
	2	100	600 (600)	140.0A --- 178.0D ---	78 ---	2.34" --- ---- --- 2.97' (2.97)	+1.53 (1.40-1.66) -5.03 (4.64-5.42) -4.96' ----	30°--30°	Peak 246 Sustain 184 50%Peak 170,Sustain60 Peak 246, Sustain 60
133 [30Sep]	2	250	300 (300)	155.0A --- 180.0D ---	78 ---	2.34" --- 15.51" --- 3.3' ---	+3.11 (2.80-3.42) -4.63 (4.61-4.64) -6.13 (5.02-7.25)	30°--30°	Peak 246 Sustain 121 50%Peak 121,Sustain60 Peak 246, Sustain 60
	2	250	600 (600)	140.0A --- 170.0D ---	79 (78-80)	2.37" (2.34-2.40) 7.0" --- 2.13' ---	+2.98 --- -5.08 --- -4.98 (4.60-5.37)	30°--30°	Peak 246 Sustain 184 50%Peak 121,Sustain60 Peak 212, Sustain 60

HOIST NRS. (DATE)	CYCLES	ALTITUDE FEET	WEIGHT POUNDS (Tension Load)	CABLE SPEED (Feet Per Min.) Average (Range) 100% SPEED INITIAL	FULL	50% SPEED	OVERTRAVEL Inches Up 50% (Range) / Inches Up 100% (Range) / Feet Down (Range)		ACCELERATION Feet/Sec/Sec	ONSET OF ±G G/Sec Initial (Range) / Max Speed(Range)	TEMP °C Motor--Winch [Increase] (Nr. of Lifts)
135 [13Nov]	3	100	300 (300)	178.7 (178-180) 188 ---	277A (255-288) 295D ---	88 ---	2.64 ---- 5.48 (4.91-6.39)	--- ---	+7.04 (6.34-7.65) -5.92 (5.56-6.11) -11.33 (10.44-13.1)	0.57(0.57-0.58) 0.08(0.01-0.15) -1.08	30°--30°
	3	250	300 (300)	122 (78-148) 188 ---	274A (270-280) 295D ---	88 ---	2.64 22.40 5.07 (4.67-5.64)	--- ---	+4.48 (3.02-5.56) -6.44 (6.11-6.79) -12.57 (11.60-13.06)	0.34(0.25-0.45) 0.03(0.01-0.06) Max Decel 0.48 0.17-0.68 -1.08	30°--30°
135 [14Nov]	3	50	200 (200)	133.7 (88-178) 188 ---	288A --- 295D ---	88 ---	2.64 28.8 7.37 (6.88-7.62)	--- ---	+5.70 (5.21-6.34) -4.42 (4.37-4.53) -10.83 (10.44-11.60)	0.50(0.44-0.57) 0.09(0.03-0.20) Max Decel 0.17 (0.05-0.29) -1.08	30°--30°
	3	100	200 (200)	178 --- 188 ---	288A --- 295D ---	88 ---	2.64 31.68 7.45 (7.37-7.62)	--- ---	+6.19 (3.36-7.61) -4.90 (4.53-5.09) -10.51 (9.49-11.60)	0.43(0.12-0.57) 0.04(0.02-0.05) Max Decel 0.10 -1.08	30°--60° Temp overheat light(After 4 min cooling following 20 lifts)
	3	250	200 (200)	188.3 (155-241) 178 ---	295A --- 295 ---	88 ---	2.64 ---- 7.21 (6.88-7.37)	--- ---	+6.09 (4.14-8.05) -4.71 (4.70-4.89) -9.96 (8.99-10.99)	0.56(0.24-0.89) 0.06(0.03-0.08) -1.02	30°--60°

Table VI summarizes by hoist numbers the lifts at each altitude and weight.

TABLE VI

SUMMARY OF HOIST DATA--WGH

WEIGHT (Pounds)	ALTITUDE (Feet)	HOIST NR 133 (125 FPM) NR	HOIST NR 135 (125 FPM) NR	(250 FPM) NR
0 (Hook)	250	---	---	20
200	50	10	---	20
	100	10	---	20
	250	10	---	20
175 (Human)	50	---	6	---
	100	---	---	12
	200	---	---	8
300	20	---	---	50
	50	---	7	41
	100	36	24	61
	250	2	---	37
400-450 (500)	50	20	---	---
	100	29	15	---
	250	0	---	---
600	50	11	10	---
	100	12	7	---
	250	20	10	---
Jungle Penetrator 20.5	50-80	23	---	---
	100-120	14	---	---
SUBTOTAL		268	79	289
TOTAL		268	368	

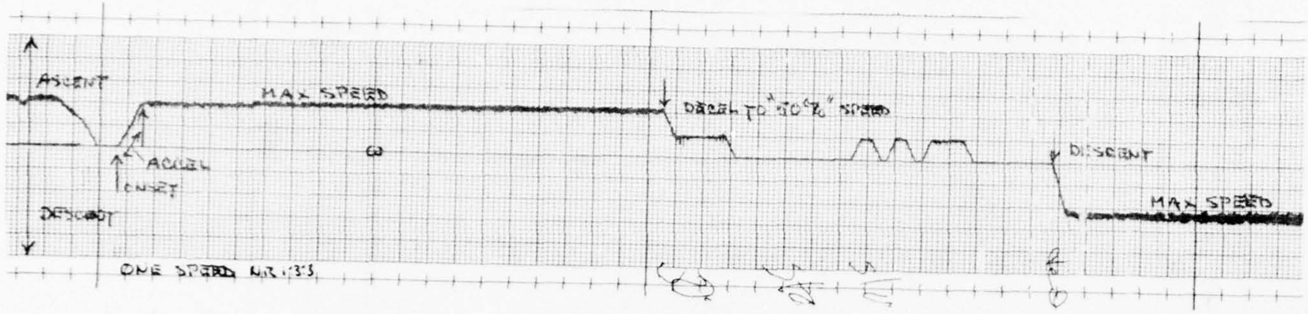


FIGURE 3 - 125 FPM

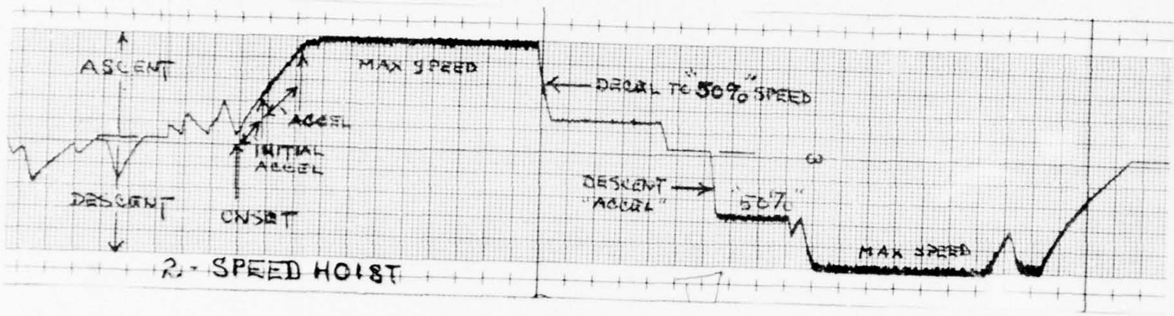
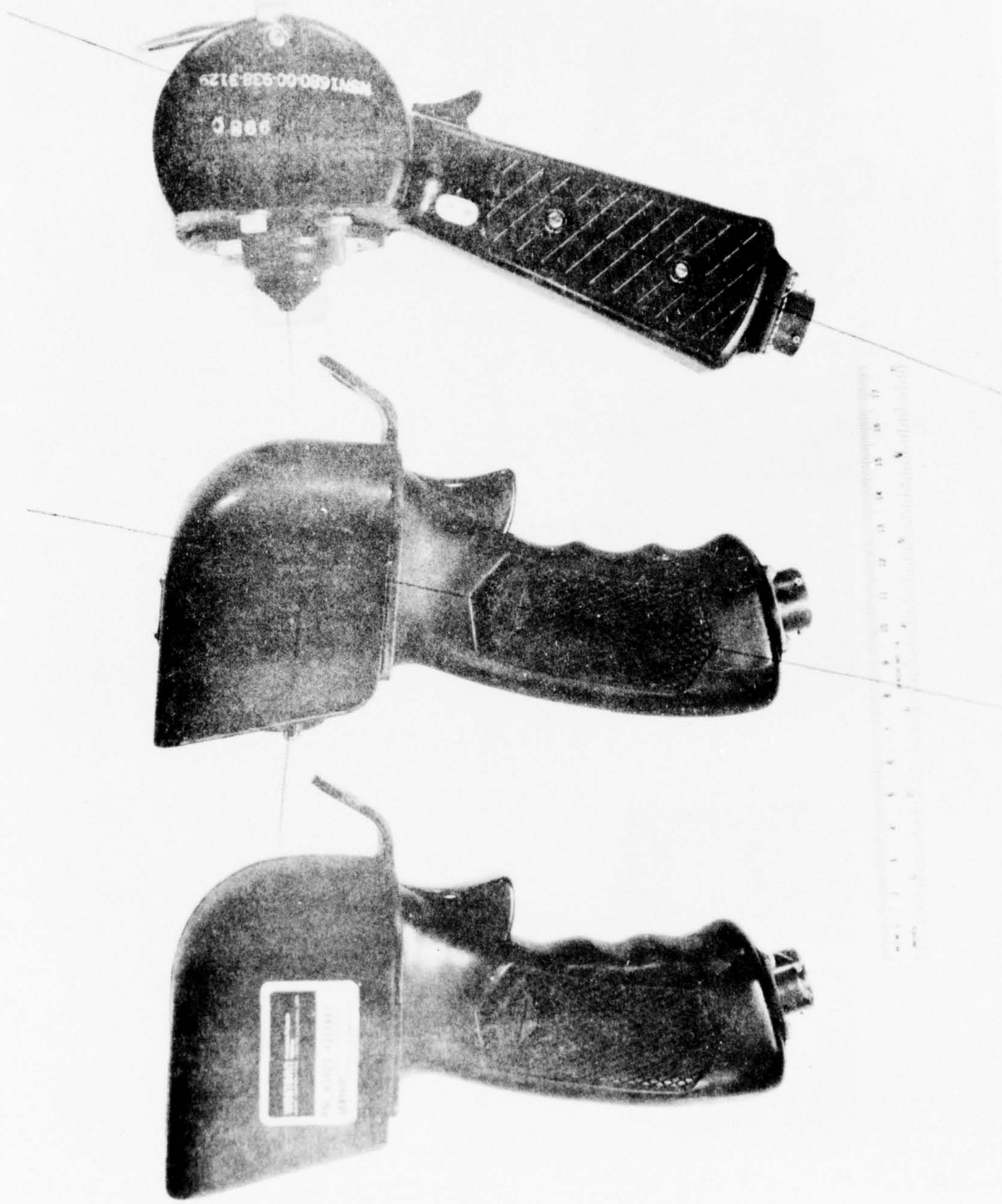


FIGURE 4 - 250 FPM



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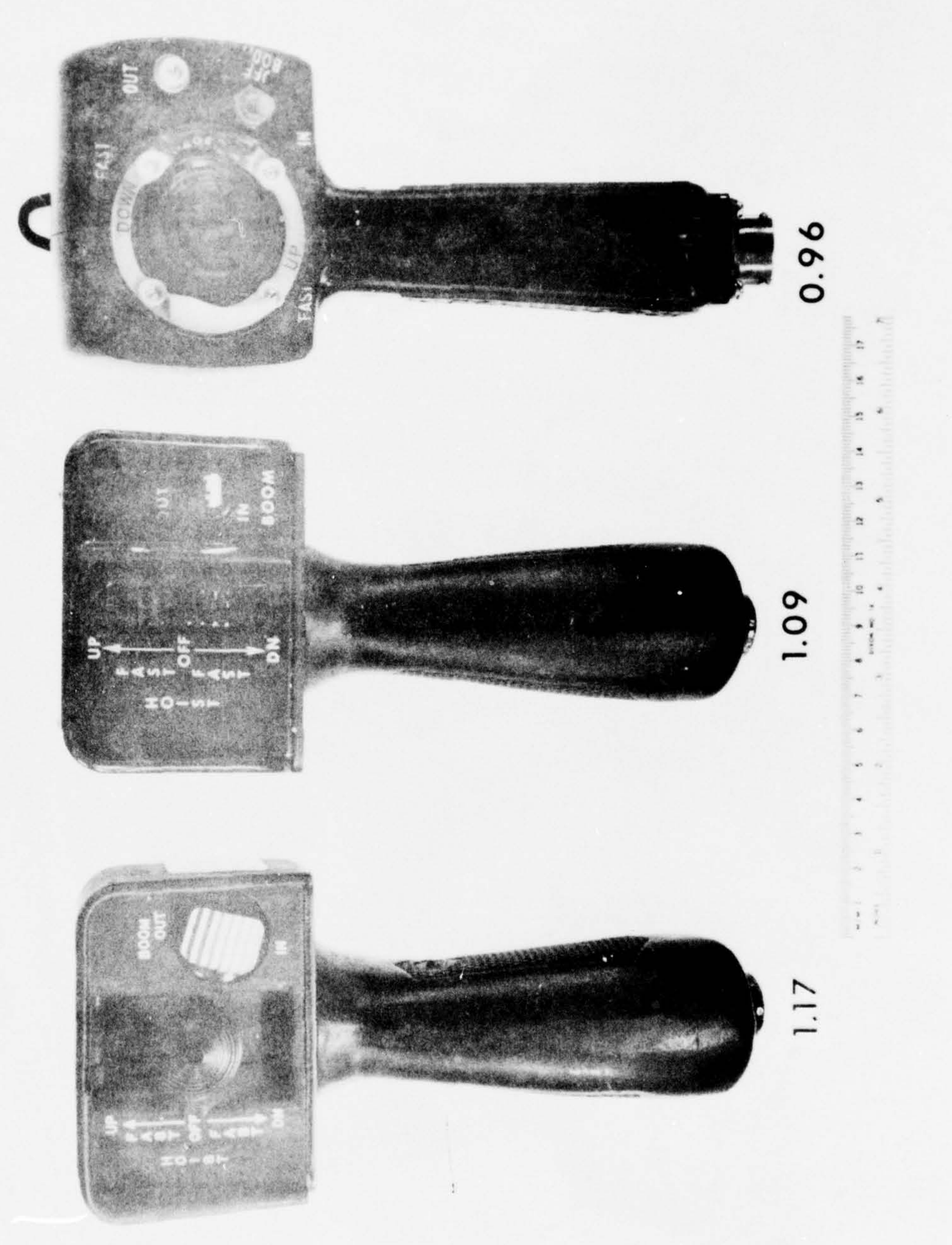

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hoist load and its proximity to the aircraft. The light was located out of the operator's visual field, thus its illumination did not provide adequate warning.

The 20-foot deceleration setting was also considered inappropriate. In operation of the single speed hoist, this deceleration to 50% of the nominal 125 feet per min (FPM) cable, in effect, produced a 62.5 FPM hoist speed at an operational altitude of 20-25 feet. In effect, this decreased the overall performance and required a prolonged JUH-1H dwell time. On 9 July the hoist, SN 131, was changed to decelerate to 50% at approximately seven (7) feet below the boom head with the resultant of deceleration one (1) foot ± below skid level. This allows the operator an additional clue as to load proximity to aircraft and prevents load-skid impact at maximal speed. These changes were subsequently made in the operation of the two speed hoist.

Vibration was encountered after 59 lifts by hoist SN 133. The WGC ascribed the vibration to "clutch chatter" on descent of heavy load. This chatter was considered to occur after the oil temperature had reached a critical point (96°C or 205°F measured by external winch housing sensor). The vibration of the JUH-1H was noticed by all aircrew. It was inconsistent in severity and intermittent in frequency. The chatter was recorded intermittently throughout remainder of instrumented and noninstrumented lifts. "Chatter" has been documented during the low temperature qualification test for BHC, page 32, par 9.3.[10] In this case, Mil H-5606 oil was being used in hoist sump. Chatter occurred at +90°F. ATF 220 (DEXRON) was reported to eliminate chatter. Hoist brake chatter was also found during endurance testing, page 88, par 18.3.3(2).[10] This occurred at 1,167 hoist cycles. WGC review of this entity provides the following information. The hoist load brake is cooled and lubricated by automatic transmission fluid (ATF) "Dexron type" which is force-fed through the brake plates. The normal operation provides a thin film of fluid between the brake plate surfaces to remove energy of lowering load by thin film "shear." This film heats as lowering occurs. As fluid reaches 175°F or greater, the viscosity "thins" and contact of metal and friction material occurs producing chatter noise. Wear of the friction material due to this chatter has not been shown to date.[10,11] The operational integrity of the hoist does not appear to be affected. Initial clutch assembly was removed and replaced. Further vibration was not demonstrated. Engineering analysis of the brake indicated all surfaces were free from wear. Clearance, however, was noted to be out of engineering tolerance.

The over temperature warning light illuminated on the two speed hoist, SN 135, after lift number 53. This malfunction was considered by WGC to be a calibration fault of the temperature sensor. The hoist was continued in the high speed mode with the warning light illuminated. Complete failure of the motor unit did not occur. The motor thermal fuses are set at 405°F to 468°F. This malfunction demonstrates an advantage operationally

providing continued lift capability with minimal cool down periods if combat conditions required.

Cable strand break was noted after lift 236 of hoist SN 133. Any cable damage is considered a primary indication for cable replacement. The strand was broken with slight uncoiling of the cable at 3 feet 2 inches from the hook which in stowed position would be at approximately 135° from vertical on drum. Tensile strength of the cable section with strand break was tested by Tinius Olsen Testing Device. Elongation of 2 inches with cable breakage at 3,200 pounds was documented (decrement of 3% from design tensile strength of 3,300 pounds).

Oil seal leaks were found on SN 131, SN 133, SN 132, and SN 135. SN 131 and SN 133 had an incorrectly installed oil seal in the boom head. SN 132 was returned to manufacturer with failure of the static O-ring seal on the idler shaft caused by a nick. The hoist seal (gatter spring) was also found displaced from its groove. Corrective action is an increased chamfer angle at the ends of the gear shaft which enters the seal and housing groove of the static "O" ring. SN 135, two speed, was delivered to USAARL with damage noted to the control panel and motor housing. The WGC engineers provided primary repair to the motor, drum, and idler shaft seals. In summary, the oil leaks were produced by:

1. Motor seal leak was produced by manufacturer failure to install lip seal spring.

2. Hoist drum seal installed improperly (inside out).

3. Idler shaft seal--"O" ring was found to be faulty (nicked). The oil leaks were minimal in quantity. In SN 131 the leak did not interfere with function during initial familiarization. The leaks of oil in the aircraft do, however, represent a hazard of loss of footing for aircrew in the cabin. These failures are indicative of poor prototype quality control.

Specific Comments - Hoist Two Speed Model 42305R1

The two speed hoist, SN 135, provided a marked improvement in hoist performance. The 50% deceleration established at approximately seven (7) to eight (8) feet below the boom head was an adequate visual and auditory cue to the hoist operator to provide increased pendant control of speed as load approached the JUH-1H. The 10% deceleration prevented excessive impact force at the boom head and was considered to function satisfactorily.

The two speed hoist developed two significant malfunctions during this initial testing. Brake "chatter" was noted intermittently and of varying intensity. The chatter occurred only on descent with load. See Table I, SN 135, 21 Nov 75. The temperature overheat light would illuminate following three to four lifts at any altitude or weight. This malfunction

is at this time presumed to indicate a faulty or miscalibrated sensor light. Testing was continued after the temperature warning light illuminated without reaching motor fuse temperature limit. Rapid and repeated lifts were made to evaluate the heat of winch to the gloved hand. The temperature remained approximately stable during these lifts.

Function of the current limiter to the two speed motor due to weight overload was evaluated. Five (5) lifts were made in high speed mode with 500 pounds. The hoist would stop or "stall" at 4 to 6 inches of lift with excess load. The WGC two speed will raise 350 pounds in high speed mode. Attempt to lift 400 pounds will produce stall. The manual control of speed is placed in low speed mode and normal lift at 125 FPM could be accomplished for the higher loads. Aircraft control was not affected by the stall condition.

Function of the boom rotation was conducted under "continuous cycle" conditions with 600 pound load. One cycle equals boom in to boom out position. Cycle time was 13 seconds. Three hundred (300) continuous cycles produced no evidence of overheat or malfunction. In the event of failure anchor pin can be removed from floor stud and boom rotated by hand.

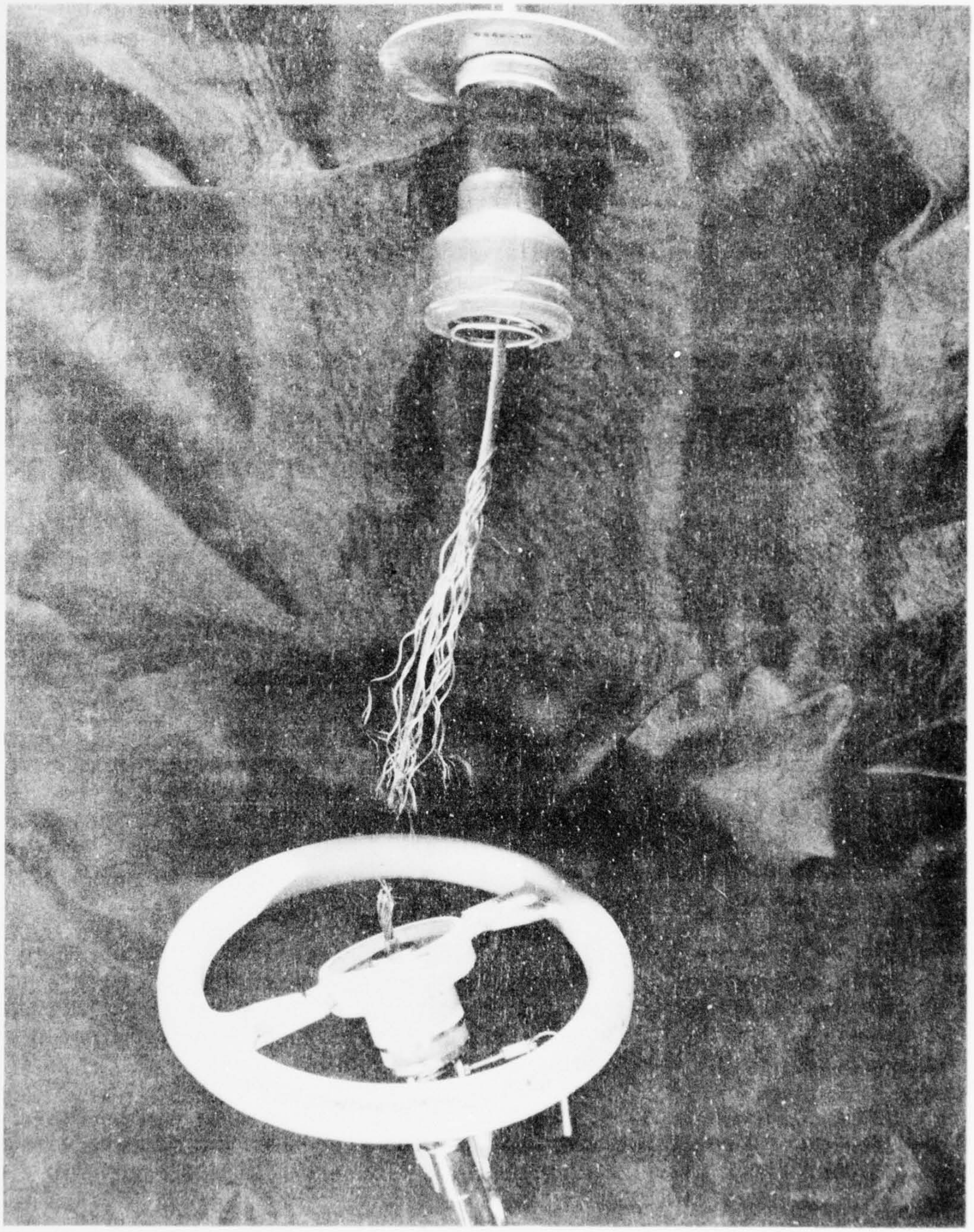
Cable cutter functioned properly on one test.

Specific Comments - Breeze ECP-720

The 720 BH hoist was demonstrated to be capable of overstressing the cable to the point of breakage. The oscillating load impacted the JUH-1H skid during a hoist of 308 pounds at 100 feet. The skid was noted to compress due to hoist. The cable broke as well as the floor deck anchor lug. Photographs M and N document the cable break position in relation to the hook. Photograph O demonstrates the shearing of anchor lug. The anchor lug is manufactured by Aeroquip-Part Nr. MS 22034-1. Shear stress breaking strength at 90° is approximately 3,000 pounds.[12] The hoist power train was thus capable of overstressing and breaking the cable in addition to the anchor lug. This is considered a CATASTROPHIC FAILURE.

The cable was a Type A, MIL-W-83140 standard cable. The ultimate strength demonstrated a relatively consistent break strength with a decrement of 0.6% to 4% from design strength of 3,300 pounds. This data is comparable to the cable test data reported by the USAF Critical Design Review (CDR) of the UH-1N Helicopter Rescue Hoist.[13]

Cable ultimate tensile strength was obtained using a Tinius Olsen load device. Three cable samples were cut from the five foot section of cable immediately above the break site. The break strength results are provided in Table VII.



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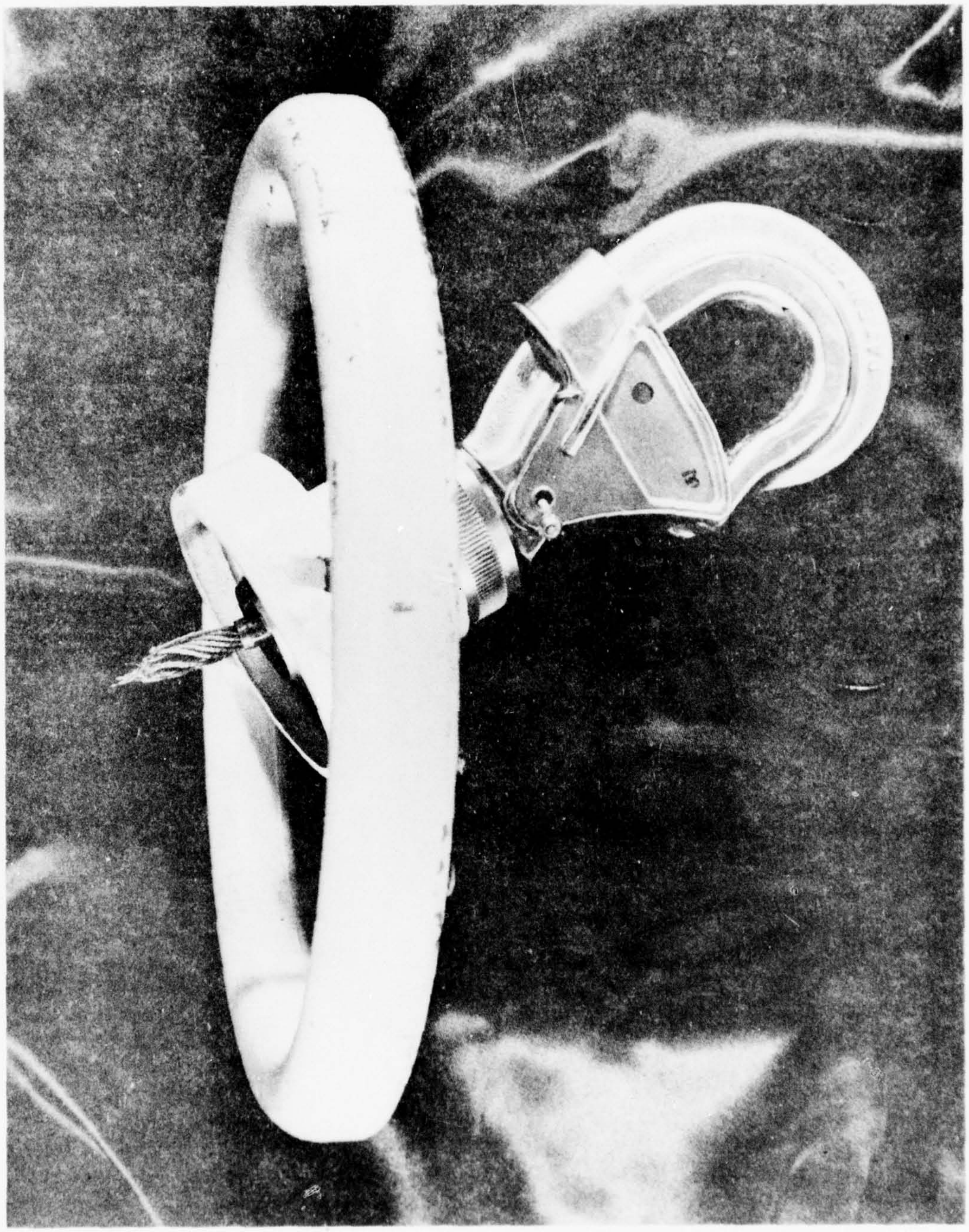

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TABLE VII

CABLE BREAK STRENGTH

CABLE SAMPLE	PRE-LOAD (Lbs)	ONSET OF LOAD (Inches Per Minute)	ELONGATION (Inches)	STRETCH POINT (Inches)	BREAK STRENGTH (Lbs)	% DECREMENT FROM 3300 DESIGN LIMIT
1	120	20	1.5	10	3170	4.0%
2	120	20	1.5	17	3280	0.6%
3	160	20	1.5	21	3240	1.8%

Cable change required an excessive amount of time by depot level maintenance organization. The cable is not capable of being changed by using unit in 30 minutes.

The amber caution light is considered to be of limited value. The hoist operator uses the cable and visual contact with the load for management as opposed to warning lights. The amber light could, however, be considered a "power on" indicator and caution. Over-temperature light is not available.

Automatic deceleration functioned appropriately.

Oil overflow due to heating occurred with full cable extension and repeated hoists. Oil overflow occurred after repeated hoists as follows:

8 lifts of 308 lbs. at 250 feet
2 lifts of 500 lbs. at 250 feet
2 lifts of 600 lbs. at 250 feet

Oil overflow represents a significant hazard to safe personnel rescue operations. The JUH-1H cabin floor became coated with the oil, producing extremely hazardous footing. The spray of oil represented a hazard to the hoist operator.

The USAF currently provides an operating data card (212-070-360-1) for the ECP-720 BH with the caution "Do not hoist or lower 600 pounds (max operating load) more than 2 times from 210 feet without a cool down period (approx. 2 hours and 30 minutes)."

In response to questions concerning temperature instrumentation, Breeze Corporation provided proprietary installation drawing BTD-263-534 which included permissible duty cycles.[14] This drawing documents the USAF recommended 2.5 hour cool down period following hoists of 600 pounds at 210 feet. The data obtained from this evaluation would support the operating recommendation of the Breeze Corporation and the USAF. This restriction is considered excessive for US Army operational requirements.

Evaluation of the ECP-720 BH boom actuator was conducted using a 600 pound load in ground position utilizing APU power to the JUH-1H. One cycle was "boom in to boom out" position. Time to complete cycle averaged nine seconds. Total cycles completed were 188. On cycle 179 the aircraft circuit breaker activated. Subsequently, attempts to provide cool down periods of 10 to 30 minutes would allow only two cycles prior to circuit breaker activation. If failure of the boom actuator occurs, it must be noted that the hoist can be unpinned and rotated by hand.

The cable cutter was activated on one occasion following completion of testing. The cable cutter functioned properly.

Safety Features - ECP-720 BH

1. The amber caution light was not considered a valid caution light.

2. Deceleration at skid level is an adequate safety feature.

3. Dual "up limit" switches are a required safety feature. Function was verified during preflight of all hoist missions.

4. Capstan, cable take-up drum, and level wind mechanism are protected by ECP-720 modifications. Water and debris, however, can still enter the overall hoist mechanism. The patient may still reach into the capstan incurring injury.

5. Sheave/boom head assembly is protected by cover.

Safety Features - WGC

1. The 20-foot caution light was not considered a valid safety feature.

2. Fifty percent deceleration at one foot below skid level is an adequate safety feature.

3. Ten percent deceleration at 6 inches is an adequate safety feature.

4. Dual up limit switches safety function was verified during preflight of all hoist missions.

5. Current limit to 150 ± 10 amperes (amps) is considered an additive safety feature. Current flow from helicopter to the hoist was recorded on hoist SN 133, 29 and 30 Sep 75. Peak system load was recorded as 246 amps with sustained amperage of 184 amps. At time of 50% deceleration, peak amps were 170 to 121 with sustained current of 60. These values are excessive and are considered to represent measurement overshoot by recording system.

6. The Inertia Dump/Torque Limiter at Main Motor Pinion was not evaluated in flight. Reference safety evaluation by WGC.[15]

Review of Hypothetical Safety Malfunctions - WGC

1. Wear of Traction Sheave Material. Wear of the traction sheave of a similar hoist manufactured by WGC for the USAF UH-1H aircraft was reported. A USAF ECP 747 recommended increase in the polyurethane material thickness from 0.062 to 0.150 inches.[11,16] This increase in thickness is incorporated into the models being tested by USAARL. Qualification Test Report demonstrated only 0.013 inches of wear of the 0.150 thickness after 7,500 cycles.[10] This wear should be considered in the periodic maintenance inspection.

2. Failure of Traction Sheave Drive Shaft. The traction sheave drive normal function allows the cable to be "reeled out" with essentially no tension load. Failure of traction drive shaft would require a hook load of ten (10) pounds or greater to "reel out" cable normally. If the ten (10) pound hook load is not available, the hold down rollers of the traction prevent cable "pay out" and a fouling of cable on the drum will occur. The usual forest penetrator weight would provide adequate load. Other devices such as the "horse collar" would not provide adequate weight for safe use in event of traction drive shaft failure. Test was not performed during this preliminary evaluation and is reported by WGC.[17]

3. Failure Producing Hoist Drum Free Spooling. A review of possible hoist drum free spooling indicates a nearly nonexistent possibility. The cable is attached to the hoist drum. Cable friction is not required. The only possibility is failure of the drum drive system shaft drive gear and idler gear. A design safety strength factor of two (2X) greater than the 3.5X ultimate load design factor (600) was incorporated. This produces a 2 x 3.5 x 600 or 4200 pound design load. WGC tests of hoist to 2700 pounds at 15° from vertical produced no slippage or creep of the load brake.[17]

Review of Hypothetical and Demonstrated Safety Malfunctions - ECP-720 BH

1. The open cable travel along boom post continues to provide for inadvertent damage to cable and/or personnel injury. Additionally, any slack in cable or empty hook allows cable to become entangled.

2. Roof and floor anchor lugs are subject to excessive stress by the hoist drive train. Additionally, the boom rotation mechanism rotates the hoist on the floor mounting stud which imparts a torque to the floor anchor lug. Wear and/or fatigue due to repeated boom actuation could contribute to failure.

3. Sheave and bell mouth function following ECP-720 modification was not fully evaluated. In-flight test of 10 payouts and retrieval of full cable length with hook only load provided no evidence of misrouting of cable. However, loose wrapping of cable was noted. The absence of a traction sheave type boom head requires cable load at a minimum of forest penetrator equivalent to be fully safe. Without load and slight cable slack, the cable fouls in open travel along post. Overstressing by binding can occur.

4. Damage to cable cutter wire at boom head connection could provide failure during a critical safety-of-flight condition. The 90° attachment allows wire to receive damage during handling.

DISCUSSION OF FINDINGS

A. ECP-720 Breeze Personnel Rescue Hoist

1. The Breeze ECP-720 Personnel Rescue Hoist was aeromedically evaluated in flight using a load range of 200 to 600 pounds. The speed was nominally 125 feet per minute. The single speed of 125 FPM is considered to be the minimum essential for combat hoist operations. It is considered less than the optimal desired speed of 250-500 FPM.

2. A cable break (CATASTROPHIC FAILURE) occurred with a test load of 308 pounds. This break occurred with oscillation of load and impact with skid. The hoist drive train was demonstrated to be capable of breaking the cable. Ultimate break strength of the contiguous cable sections was within acceptable limits.

3. Repeated hoists of the maximal weights, 500-600 pounds at 200-250 feet, produced rapid rise in oil temperature with venting of oil through vent port. This produced a hazard for the hoist operator as well as possible fouling of hoist mechanism.

4. Boom actuator was demonstrated to fail after repeated hoists (180 cycles) with maximum load. Failure was due to overheating. Cool down of 30 minutes was unsuccessful in restoring function.

5. Safety features of ECP-720 were considered the minimal of the available state-of-the-art to attempt to correct "life or death" restriction. Due to CATASTROPHIC FAILURE (cable break), the ECP-720 could not be considered fully corrective of "life or death" restriction.

6. Cable fouling was considered easily accomplished due to absence of traction sheave type boom head if cable payout without load and slack in cable occurs.

7. Protection of primary components (capstan, level wind mechanism, and cable drum) from debris, water, or mud was improved by ECP-720 but remains incomplete.

8. Cable change required depot level maintenance. Cable and explosive cable cutter charge could not be replaced in 30 minutes by using unit.

9. Weight of hoist plus base plate was 179 pounds which is within the limit of 180 pounds.

10. During repeated hoisting, electrical feedback intercom noise indicated decremental slowing of hoist speed. This effect was not documented by the nonlinear tachometer method utilized.

11. Installation time and training requirement were within operational needs.

12. Evaluation of ECP-720 BH pendant control demonstrated "best" angle for thumb fine control of hoist speed.

13. The use of caution light is of use only as a "power on" indicator. The position is out of visual field of hoist operator. Power on/cable caution light should be placed on boom with directional shielding.

14. The Hour meter is considered necessary to provide use/maintenance data.

15. Acceleration and rate of onset data were not obtained due to nonlinear tachometer.

16. Cable marking is an essential operator control assistance device.

17. Severe climatic conditions were not studied.

18. The Breeze ECP-720 hoist was compatible with the usual rescue devices, i.e., forest penetrator, litter, sling, and personnel rescue harness.

19. Cost of Breeze hoist procured to ECP-720 configuration is excessive. (USAF procured 11 hoists at $33,294 each; USN, 24 Mar 76, procured 12 hoists at $43,804 each.)

B. Western Gear Hoist Single and Two Speed Rescue Hoists

1. The WGH single and two speed hoists were aeromedically evaluated in flight using a load range of 200-600 pounds. The hoists were overall operationally excellent. The two speed hoist, 250 FPM/300 pounds and 125 FPM/600 pounds, provided a marked increase in operational capability by decreasing helicopter hover time and time for repeated hoists.

2. Cable strand break was noted on one occasion. This is a primary indication for cable change. Tensile break strength testing of strand break area demonstrated cable to be within acceptable limits.

3. Continuous cycle trials of hoists using maximal weight of 500-600 pounds and maximal cable length of 200-250 feet produced "chatter" of clutch due to increasing temperature effect on transmission fluid shear qualities during descent. This occurred only after repeated hoists in excess of scenario. This finding is considered acceptable in view of hoist continued function.

4. Boom position actuator was demonstrated to perform at maximal load through 300 continuous cycles without degradation or overheat.

5. Safety features of WGH single and two speed hoists were found to incorporate the current state-of-the-art technology to include dual-up switches, current limiter (in addition to aircraft current limit), automatic deceleration of 50% of skid level, 10% at boom head, and inertia/torque limiter at main motor pinion. Redundancy of safety features directed towards cable protection are considered corrective of the "life or death" restriction.

6. Cable fouling could not be demonstrated to occur by cable payout or retrieval without load.

7. Protection of primary components of hoist from debris, water or mud during operation was considered to be adequate due to primary controls and components mounted above aircraft deck area.

8. Cable and explosive cable cutter charge were easily accomplished by using unit within 30 minutes with tools readily available in TOE tool kits. This is considered a significant asset in the operational employment of the hoist.

9. Weight of the single speed hoist is 169 pounds. Weight of the two speed hoist is 171 pounds. Both are within the acceptable design limit of 180 pounds.

10. Minor electrical feedback into intercom was noted. The operator is capable of using this feedback as ancillary clue to hoist speed control specifically for distance limit lifts (200-250 feet).

11. Pendant control using roller bar is considered adequate. It is recommended redesign of angle to provide increased fine control using the operator's thumb.

12. The use of caution light mounted on control box is considered nonusable. This position is well out of the visual field of hoist operator. It is recommended that a combined power-on cable caution light be placed on the boom head if possible.

13. The Hour meter was installed as a modification on the two speed WGC hoist. The meter is considered essential to hoist maintenance and to insure timely cable or component change.

14. Acceleration onset levels recorded are slightly in excess of the 0.5G/sec. during ascent and deceleration (0.57G/sec.). This is considered to be within acceptable physiologic limits.

15. Cable marking at 10 foot increments was considered useful to operator as an ancillary control measure.

16. Severe climatic studies were not performed.

17. The WGC hoists were demonstrated to be compatible with the usual rescue devices, i.e., forest penetrator, litter, sling, and personnel rescue harness.

18. The modular configuration provides for ease of component replacement/maintenance. Modular components may be utilized in other type aircraft, i.e., UTTAS.

19. Estimated cost of WGC two speed hoist is $19,000 each. (See Table VIII for comparison.)

20. Hoist configuration provides conservation of cabin space and door opening in operating position.

CONCLUSION

Table VIII provides WGC and ECP-720 BH hoist comparison with the design Required Operational Capability.

The Breeze ECP-720 Personnel Rescue Hoist modification was demonstrated to be inadequate to remove the "life or death" restriction. Cable damage and fouling capability remains.

The Western Gear Corporation two speed hoist, 42305R1, demonstrates current state-of-the-art technology. The advantage of increased speed, redundant safety features, capability of essentially unlimited continuous cycle hoisting, modularization, rapid cable and cable cutter charge within 30 minutes by using unit are self evident.

TABLE VIII

HOIST COMPARISON

Required Operational Capability and Production Hoists

HOIST CAPABILITIES	ROC	WESTERN GEAR 42277R1 (ONE SPEED)	WESTERN GEAR 42305R1 (TWO SPEED)	BREEZE (ECP-720)
Capacity (Pounds)	UH-1H 600/300	600	600/300	600
Speed (FPM)	UH-1H 0-125 FPM (600)	0-143.6 UP, 175.4 DOWN WITH LOAD	Not Studied	0-123.4 UP, 154.2 DOWN WITH LOAD
	0-250 FPM (300)	Not Applicable	0-284.4 UP, 295.0 DOWN WITH LOAD	Not Applicable
Acceleration	Limits 1G (32.2 Ft/Sec/Sec)	+8.04 Ft/Sec/Sec Max -7.25 Ft/Sec/Sec Max	+8.05 Ft/Sec/Sec Max -13.1 Ft/Sec/Sec Max	Acceleration could not be calculated due to nonlinear tachometer.
	Onset of G--0.5 G/Sec	Not Verified	+0.89 G/Sec Initial Max +0.20 G/Sec Max Speed -1.08 G/Sec	As Above
Cable				
Cable load limit 1200 lbs.		Not Verified	Not Verified	Not verified. Cable break occurred with 308 lbs. on contact with JU-1H skid.
Static load limit (15°) 2300 lbs.		Not Verified	Not Verified	Not Verified

HOIST CAPABILITIES	ROC	WESTERN GEAR 42277R1 (ONE SPEED)	WESTERN GEAR 42305R1 (TWO SPEED)	BREEZE (ECP-720)
Cable (Continued)				
Cable length (Max) 250 ft.		250 ft.	250 ft.	250 ft.
Cable ultimate strength 3300 lbs. (GFE)		Not Verified	3200 (Strand broken)	2170-3280 (Adjacent Break)
Max Hoist Weight	All components--180 lbs.	169 lbs.	171 lbs.	179 lbs.
Cable Lift Angle 45°				
90° cone angle, boom head swivel 60° from vertical--Total 120°		+	+	+
Actuator Boom Position Function	Not Specified	Not Studied	Time 13 Secs--300 cycles without failure	Time 9 Secs--Fail at 179 cycles due to overheat
Safety Features				
Dual up limit switches		+	+	+

HOIST CAPABILITIES	ROC	WESTERN GEAR 42277R1 (ONE SPEED)	WESTERN GEAR 42305R1 (TWO SPEED)	BREEZE (ECP-720)
Safety Features (Continued)				
Automatic deceleration		+	+	+
Current limiter (hoist)		+	+	+ (Aircraft Circuit Breaker Only)
Inertia/torque limiter (main motor pinion)		+	+	0
Traction sheave		+	+	0
Cost K = $1000	Not Specified	18K per hoist	19K per hoist	33-43K
Operational Factors				
Cable change by using unit within 30 minutes		+	+	0
Continuous cycle operation		+	+	0

NOTE: + = Available
0 = Not available

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ARL 77-7

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UNCLASSIFIED

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2. Helicopter rescue hoist
3. Rescue
4. Aeromedical evacuation

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